

# A Look at the Components and Effectiveness of Sports Drinks

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**ABSTRACT:** *The confusion about sports drinks is lessened if the types are understood. Types include: fluid replacers, carbohydrate loaders, and nutrient supplements. The athletic activity and the timing of the consumption of the drink need to complement the type of drink. Fluid replacement is a must before, during, and after activity to maintain heart rate and body temperature. Whether water or a sports drink is consumed is the athlete's choice. The carbohydrate concentration of a fluid-replacing drink should not exceed 10%, which is comparable to the gastric emptying characteristics of water. Glucose, sucrose, and glucose polymers are all well tolerated by athletes during activity, although fructose in high concentrations may not be. Electrolytes are present in drinks to enhance absorption; high levels usually are not needed, except in certain populations.*

An important aspect of athletic activity is proper hydration. Fluid loss occurs in any climate, but is more detrimental in areas with high temperatures and humidity. A weight loss of greater than 2% resulting from dehydration can fatigue the athlete, cause a loss of concentration, increase heart rate, and lead to circulatory collapse (3,10,11,13).

One role of an athletic trainer is to ensure that athletes are properly hydrated throughout activity. Water is the most common fluid replacer. Some athletic trainers are fortunate enough to have the resources

to provide sports drinks to their athletes. The athletes, therefore, have the opportunity to choose between water and sports drinks. The "ideal" sports drink should provide: (1) a rapid gastric emptying rate; (2) a body fluid balance; (3) minerals that are typically lost through sweat; and (4) an adequate carbohydrate source to aid in energy supply and performance (10,13).

Because an abundance of sports drinks are on the market today, athletes as well as athletic trainers are being bombarded with new products claiming superiority over existing ones. This has caused a great deal of confusion, leaving it unclear about which type of drink to use and when.

The purpose of this article is to help lessen the confusion about sports drinks. As the athletic trainer considers the use of a sports drink, he or she should examine the activity of the athlete. Also, the drink should be analyzed for its hydration properties, its gastric emptying and absorption rates through the small intestine, and the types of carbohydrates and electrolytes present in the drink.

## Types of Sports Drinks

There are three types of sports drinks on today's market—fluid replacers, carbohydrate loaders, and nutrient supplements. Each is designed for a specific use and should not be used for other purposes.

### Fluid Replacing Drinks

Fluid replacing drinks include Exceed Fluid Replacement Drink, Gatorade, 10-K, Quickkick, Max, and Carboplex II (1,4,7). These drinks are absorbed as quickly as water and typically are used in activities lasting less than 2 hours. Fluid replacing drinks can be used in place of water and should be consumed before, during, and after physical activity. Many of the fluid

replacers contain glucose polymers that provide a faster gastric emptying rate and an energy source (10). Therefore, some of these drinks fit into two categories—fluid replacing drinks and carbohydrate loading drinks.

### Carbohydrate Loading Drinks

The second category is the carbohydrate loading drinks, which includes Shaklee Performance Maximum Endurance Sports Drink, Gatorlode, Exceed High Carbohydrate Source, and Carboplex (1,4,7). The difference between fluid replacing and carbohydrate loading drinks is that the carbohydrate loaders produce more muscle glycogen for greater endurance. These drinks should be used before and after ultraendurance events to increase muscle glycogen resynthesis after exercise (13).

### Nutrient Supplement Drinks

Finally, there are the nutrient supplement drinks like Gatorpro, Exceed Sports Nutrition Supplement, and Ultra Energy (1,4,7). These supplements are fortified with vitamins and minerals and they help athletes to maintain a balanced diet. Athletes who need to lose weight can use these drinks to replace some of their food intake that is high in fat and calories. Conversely, such a drink may be taken with meals to increase caloric content to gain weight.

### Gastric Emptying

Gastric emptying is the process by which the contents of the stomach are emptied into the small intestine. The two main factors that stimulate gastric emptying are: (1) nerve impulses that act in response to stomach distension; and (2) the action of gastrin, a hormone released from the pyloric mucosa in the presence

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of partially digested proteins (15). The emptying rate is also influenced by the caloric content, volume, osmolality, temperature, and pH of the fluid in the stomach; diurnal variation; metabolic state; and ambient temperature (2,11,12).

Foods rich in carbohydrates are quickly digested and leave the stomach most rapidly. Proteins take longer. Fats are digested and moved to the small intestine slowly (15). Foods and beverages similar in caloric content empty from the stomach at similar rates (2). However, excessive caloric intakes will delay gastric emptying (12). While moderate exercise (<70% VO<sub>2</sub> max) does not affect gastric emptying rates, intense exercise inhibits emptying by shunting blood flow away from the gastrointestinal tract to the working muscles (12,13).

Drinks containing more than a 2.5% carbohydrate content have been shown to delay gastric emptying (2,10). However, one study conducted by Murray (12) contradicts this statement. He found that when fluids were consumed at regular intervals throughout prolonged exercise (greater than two hours) postexercise aspiration revealed that solutions containing up to 10% carbohydrates empty at rates similar to water. This is supported by the fact that glucose and sodium stimulate fluid absorption in the small intestine (2,11,12).

Solutes contained in sports drinks are classified as penetrating or non-penetrating. Nonpenetrating solutes set up an osmotic gradient that does not allow water to enter the osmoreceptor in the cell; therefore, these shrunken vesicles slow gastric emptying. The smaller the receptor, the slower the emptying of the stomach. Large amounts of hypertonic solutions keep the osmoreceptors shrunken and delay gastric emptying. Rehydration drinks with carbohydrates are examples of non-penetrating solutes. Consuming these types of drinks results in a relatively constant stomach volume maintained by gastric secretion and some emptying into the small intestine (3).

Penetrating solutes enter the vesicle, reverse the osmotic gradient, and enlarge the vesicle. The enlarged vesicle decreases the inhibitory signal while increasing gastric emptying. Isotonic sodium chloride is an example of a penetrating solute (13,14).

In a study by Foster et al (6), a 5% polymerized glucose solution was emptied from the stomach faster than a 5% free glucose solution. They found that 69% more fluid and 33% more carbohydrate

were delivered to the small intestine after thirty minutes of exercise with the 5% polymerized glucose than with the free glucose solution (6). In comparing 7% and 10% polymerized glucose solutions, they found that the more dilute the solution, the faster the gastric emptying.

In selecting a sports drink, the certified athletic trainer should match the gastric emptying characteristics of the sports drink with the type of activity of the athlete. For example, an ultraendurance athlete may benefit from a drink containing glucose polymers. Glucose polymers are absorbed as quickly as water to prevent dehydration, but they also provide enough carbohydrates to delay fatigue. Other athletes, such as football and basketball players, would benefit more from using fluid replacing drinks because they sweat heavily.

## Types of Carbohydrates

As stated earlier, the type of carbohydrate has no major influence on the rate of gastric emptying, provided that the concentration of carbohydrate is low (13). Simple carbohydrates, such as sucrose, glucose, fructose, and/or glucose polymers (also known as maltodextrins), are added to the sports drinks on the market. Each are included according to the main purpose of the drink, ie, nutrient supplementation, carbohydrate loading, or fluid replacement.

Glucose polymers are chains of glucose molecules that are shorter than starches, but longer than simple sugars (17). Polymers are more beneficial to the athlete than simple carbohydrates because they pass through the stomach more rapidly (13). Simple carbohydrates and glucose supply energy and maintain fluid balance in the range of 5 to 10% carbohydrate concentration (1,12). Glucose polymers are used in drinks to increase the carbohydrate content up to 15%, which renders them more palatable, and to increase the gastric emptying rate. At the same time, they minimize the osmolality, because they decrease the effect on osmoreceptors while increasing gastric emptying (13).

Glucose, maltodextrin, and sucrose all stimulate fluid absorption in the small intestine. These solutes, when consumed during exercise, have similar effects on cardiovascular thermoregulatory responses and performance (2). Fructose is absorbed more slowly than other carbohydrates and does not stimulate as much absorption of fluid (2).

Fructose is not associated with perfor-

mance improvement, possibly because it cannot be metabolized and released rapidly enough by the liver to provide adequate amounts of glucose to the working muscles (2). Fructose is not associated with rebound hypoglycemia, but does support hepatic and tissue glycogen resynthesis to a greater degree than does glucose. Muscle glycogen is spared after submaximal exercise with the intake of fructose (13). Gastrointestinal distress and diarrhea are common side effects of drinking solutions containing fructose during exercise, especially at 10% or greater concentrations (1).

Fructose, however, in high concentrations would not be beneficial in fluid replacing drinks because of the slow absorption rate. Carbohydrate loading drinks containing fructose, used days prior to an event, would give the body time to produce more glycogen.

As with the gastric emptying rate of a sports drink, the carbohydrate present in a drink should be matched to the specific use of the drink. Glucose polymers, because of their unique properties, are used as well as glucose and sucrose in both carbohydrate loading and fluid replacing drinks.

## Electrolytes

Electrolyte requirements for any individual can be met by consuming a balanced diet. However, fluid and electrolyte imbalances may occur in certain circumstances, such as when individuals are on sodium-restricted diets or are in the early stages of acclimation to a hot environment. In addition, imbalances may occur during prolonged, repeated exposure to exercise and heat, and during exercise lasting several hours (2,12). Among the important electrolytes are sodium, chloride, potassium, magnesium, and calcium, which are often included in glucose-containing electrolyte drinks.

Sodium helps maintain proper body fluid volume. Small amounts of sodium improve water and glucose absorption in the body. Glucose-electrolyte solutions maintain body fluid balance better than glucose drinks alone (2). Sodium also plays an important role in muscle contraction and in the conduction of nerve impulses. A slight deficiency of sodium may impair performance, causing nausea, vomiting, headache, loss of appetite, muscular weakness, and leg and abdominal cramps (17).

One common electrolyte imbalance seen in ultraendurance athletes is

hyponatremia or water intoxication. As a result of an excess of sodium lost through sweat, a sodium deficit occurs. This condition could be further complicated by the ingestion of water or other low-sodium beverages during exercise. A sodium loss of 500 to 1000 mg per pound of sweat can be life threatening (1,2). For individuals with the potential for developing hyponatremia, the ingestion of sodium while exercising will help maintain and restore the plasma volume during exercise and recovery. Beverages containing sodium help retain water in the extracellular space while promoting thirst. Drinking plain water tends to decrease plasma osmolality, leading to a decreased desire to continue drinking. Therefore, plasma volume is not adequately restored, because fluid intake is insufficient.

Ingesting sodium before exercising, an activity that many coaches suggest, is not recommended for all athletes. Sweat contains more water and less sodium and potassium than does blood plasma. Exercise and heat exposure often cause an increased concentration of electrolytes in the plasma. Because the concentration increases, added intakes may disturb normal electrical activity in the heart and muscles, with possible severe consequences such as heat illnesses and cardiac arrest (17).

The role of chloride in athletic activity is similar to that of sodium in regulating electrical potentials across cell membranes. The loss of chloride in sweat is proportional to the loss of sodium (17). Potassium also plays a role in muscle contraction and nerve impulse conduction. In addition, it aids in the storage and transport of glycogen across the cell membrane (17).

Magnesium assists in the formation of adenosine triphosphate (ATP) and regulates neuromuscular transmission, muscle contraction, and protein synthesis. Chronic diarrhea and vomiting may lead to a deficiency of magnesium, which is rare, but results in muscle cramps and weakness. Each day, athletes should consume 8 mg/kg of body weight (17). That amount is important for normal recovery after activity and helps prevent muscle cramps.

Calcium has a role in the formation of bones and teeth, muscular contractions, transmission of nerve impulses, blood clotting, and glycogen metabolism. An excess

of calcium in the body leads to an abnormal heart rate and muscular weakness. A deficiency leads to muscle cramps and impaired physical performance by disrupting normal neuromuscular functioning (17).

A minimal amount of these electrolytes are lost through sweat. A well-balanced diet sufficient in these elements, prior to activity, should keep the body fluid balanced to avoid detrimental losses. The recovery meal also should be adequate in minerals to replenish the losses from the activity. Again, these elements are included in sports drinks to improve the absorption rate and fluid balance in the body.

## Performance Improvement

The idea of performance improvement through the use of sports drinks is a very controversial topic. Some studies conducted have found improvements (2,9,10,13) and others have not (5,17). Mechanisms for improvement are unclear. Carbohydrate feeding during exercise may spare muscle and liver glycogen. When muscle glycogen stores become depleted during exercise, carbohydrate feedings may maintain the blood glucose levels, allowing carbohydrate use and energy production to continue at high rates (2).

Performance improvement is associated with the consumption of at least 25 to 30 g of carbohydrate each hour. Fluids with a 6% carbohydrate solution can achieve this. The American College of Sports Medicine recommends 4 to 8 oz of fluid every 15 to 20 minutes during exercise (2).

Work by Wahren et al demonstrated that ingestion of a hypertonic 30% carbohydrate solution resulted in an increased glucose uptake and oxidation in the working muscle, decreased fat mobilization, increased gluconeogenesis, and a greater glucose release from the liver. This would result in using the carbohydrate too fast and from the wrong sources.

Work by Ivy et al (8) found that while carbohydrate supplementation did not improve overall performance significantly, the onset of fatigue was delayed during the last 30 minutes of an exercise bout. With carbohydrate supplementation, the exercise performed during the last 10 minutes was of greater intensity than that performed in the first 10 minutes.

If a high carbohydrate diet precedes athletic activity, the type of sports drink ingested has no effect on performance improvement. If glycogen stores are low prior to activity, the carbohydrate consumed in a drink during activity will spare muscle glycogen. During prolonged exercise (>2 hours), carbohydrate loading drinks can help maintain glucose levels.

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